J. Raptor Res. 24(3):47–51

DENSITY AND HABITAT USE OF RAPTORS ALONG THE RIO BAVISPE AND RIO YAQUI, SONORA, MEXICO

RICARDO RODRIGUEZ-ESTRELLA
Centro de Investigaciones Biologicas, Apdo. Postal 128, La Paz, 23000, Baja California Sur, Mexico

BRYAN T. BROWN
P.O. Box 3741, Tuscon, AZ 85722

ABSTRACT.—Raptor populations of the Rio Yaqui and one of its principal tributaries, the Rio Bavispe, of Sonora, Mexico, were surveyed by boat in the early spring of 1987 and 1988. The purposes of this survey were to document population status, to examine patterns of habitat use, and to compare raptor abundance between rivers. Turkey Vulture (*Cathartes aura*) and Black Vulture (*Coragyps atratus*) were the two most abundant raptors in the study area, although most vultures observed during the study period appeared to be migrants. Nesting raptors included Bald Eagle (*Haliaeetus leucocephalus*), Red-tailed Hawk (*Buteo jamaicensis*), Common Black-Hawk (*Buteogallus anthracinus*), and Peregrine Falcon (*Falco peregrinus*). Common Black-Hawk was the most abundant nesting raptor, exhibiting a density of 0.35 pairs/km in riparian woodland along the Rio Bavispe, the highest reported density for this species in Mexico. Common Black-Hawks were strongly associated with riparian areas dominated by dense stands of large Honey Mesquite (*Prosopis glandulosa*) and Pithecellobium (*Pithecellobium mexicanum*), a habitat that has apparently increased in extent due to the operation of an upstream dam and reservoir. Bald Eagles and Peregrine Falcons nested on riverside cliffs.

Densidad y uso del habitat por aves rapaces a lo largo del Rio Bavispe y del Rio Yaqui, Sonora, México

EXTRACTO.—Durante el inicio de la primavera de 1987 y 1988 se censaron las poblaciones de aves rapaces del Río Yaqui y del Río Bavispe, en Sonora, México. Los ríos fueron recorridos en canoas con el propósito de registrar la abundancia de aves rapaces y determinar los patrones del uso del habitat que las diferentes especies tienen en los dos ríos. El Aura Común (*Cathartes aura*) y el Zopilote Negro (*Coragyps atratus*) fueron las rapaces más abundantes en los censos, aunque la mayoría de los individios eran problamente migratorios. Las especies que se reproducían en la zona incluyen el Aguila Calva (*Haliaeetus leucocephalus*), el Aguililla colirroja (*Buteo jamaicensis*), el Aguililla Cangrejera (*Buteogallus anthracinus*) y el Halcón Peregrino (*Falco peregrinus*). La especie que anidaba más abundantemente fue el Aguililla Cangrejera, con una densidad de 0.35 pares/km en el bosque de galería del Río Bavispe. Esta es la más alta densidad reportada para la especie en México. El Aguililla Cangrejera estuvo particularmente asociada a áreas densas dominadas por Mezquite (*Prosopis glandulosa*) y por Palo Fierro (*Pithecellobium mexicanum*), un habitat que se ha incrementado debido aparentemente a la operación de una presa ubicada en la parte alta del río. El Aguila Calva y el Halcón Peregrino fueron vistos anidando sobre los riscos que bordean el río.

Few studies exist regarding raptor populations of Mexico (Wetmore 1943, Friedmann et al. 1950, Thiollay 1977, 1978, 1979, 1980). Most of these studies were conducted in eastern Mexico and few relate to raptor status and habitat use in the more arid northwestern portion of Mexico. Here we present information on the density and habitat use of raptors along the Rio Yaqui and one of its principal tributaries, the Rio Bavispe, in Sonora, Mexico. Special attention has been focused on nesting raptors associated with riparian zones, particularly Common Black-Hawk (*Buteogallus anthracinus*).

STUDY AREA

The Rio Yaqui, the largest river of Sonora (Fig. 1), is formed by the confluence of its major tributaries, the Rio Aros and Rio Bavispe. The study area consisted of the Rio Bavispe from the town of Granados downstream to its confluence with the Rio Aros (65 km) and the mainstream Rio Yaqui from the Aros/Bavispe confluence downstream to the El Raspadero Mine at the head of the

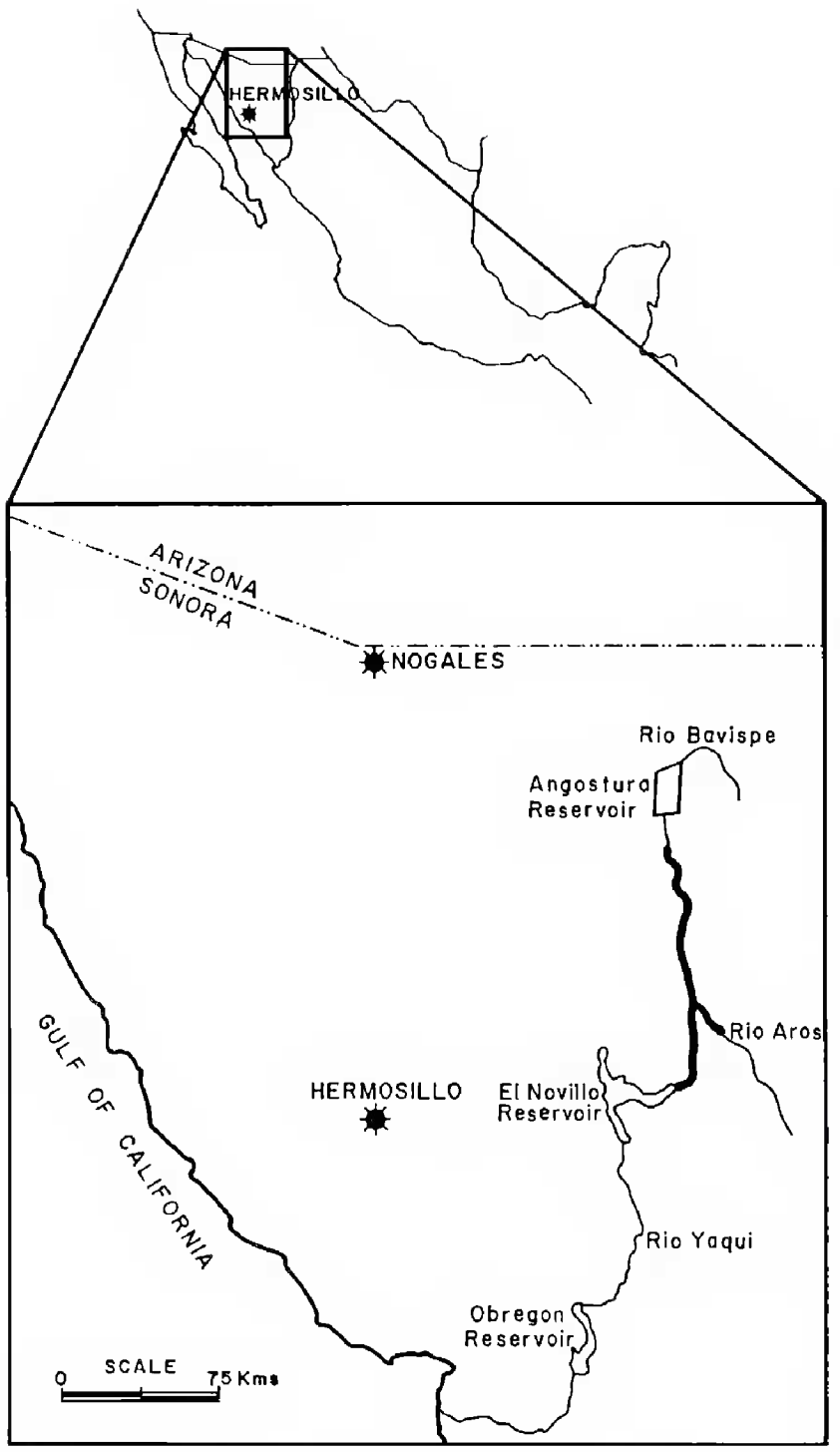

Figure 1. The Rio Bavispe and Rio Yaqui study area was surveyed in 1987–1988. Bold line shows the portions of each river censused.

El Novillo Reservoir (80 km). Elevations along the river range from 520 m at Granados to 330 m at the El Novillo Reservoir; mountain peaks adjacent to the rivers rise to over 1800 m. The Rio Bavispe flows through relatively narrow canyons, while the Rio Yaqui flows through a broad canyon. Cliffs up to 100 m in height occur infrequently along both rivers. Upland vegetation consists of subtropical, winter-deciduous thornscrub averaging 10 m in height dominated by *Lysiloma divaricata, Acacia cochliacantha, Ceiba acuminata, Cercidium praecox, Mimosa dysocarpa,* and *Fouquieria macdougalii* (White 1948).

Riparian vegetation consisted of Pithecellobium (*Pithecellobium mexicana*), Honey Mesquite (*Prosopis glandulosa*), Gooding Willow (*Salix gooddingii*), Fig (*Ficus petiolaris*), Canyon Ragweed (*Ambrosia ambrosioides*), Soapberry (*Sapindus saponaria*), and a few scattered cottonwoods (*Populus fremontii*) and palms (*Erythea roezlii*). Riparian vegetation also invaded narrow floodplains in the river canyons (White 1948).

Riparian vegetation of the Rio Bavispe, and to a lesser extent the Rio Yaqui, has been modified by the upstream construction and operation of the Angostura Reservoir on the Rio Bavispe since the mid 1930s. The dam eliminated the large annual floods which had formerly scoured away all vegetation below the pre-dam high water mark, allowing a dense new zone of woody vegetation to develop at the post-dam river's edge. Although the extent of this increase in riparian habitat is undocumented, our qualitative observations suggest that Mesquite- and Pithecellobium-dominated riparian woodland along the Rio Bavispe increased several hundred percent, from an estimated pre-dam 50 ha to a post-dam 200 ha. A continuous, dense band of closed-canopy, even-aged riparian woodland dominated by Mesquite and Pithecellobium averaging 12 m in height had formed along the Rio Bavispe by the 1980s. This is analogous to the increase in extent of riparian vegetation documented along the Colorado River in Arizona after the completion of Glen Canyon Dam (Turner and Karpiscak 1980). Riparian vegetation was less well-developed along the Rio Yaqui due to the recurrence of annual floods from the undammed Rio Aros.

The riparian zone of the Rio Yaqui was greatly disturbed by human activities including agriculture, grazing, mining, roads, and the presence of several small ranches and a village. The Rio Bavispe was relatively undisturbed except for grazing and the presence of two small ranches.

METHODS

We surveyed raptor populations in the study area from 24 March to 2 April 1987, and from 7–14 April 1988. The surveys were made from canoes as we floated downstream, censusing a distance of 15–20 km/day. Up to eight skilled observers participated in the surveys.

Each survey was designed as a continuous transect (Fuller and Mosher 1981) where the transect length was the length of the river traversed in km. All raptors observed within 0.5 km of the river were recorded between 1000 and 1800 H, the range of times when we were actively moving downstream. For each raptor we recorded species, location, indications of breeding, if any, and habitat. We classified the study area into five major habitats: Pithecellobium and Mesquite, Gooding Willow and Pithecellobium, Mesquite, upland mountain or cliff, or disturbed areas. Habitat occurrence for raptors whose nest location was known was classified according to the nest location; habitat occurrence for raptors whose nest location was not known was classified according to the initial habitat in which they were observed.

Several techniques, including the continuous visual transect, nest searches, and observations of territorial behavior, were used to determine raptor abundance. Nest sites of cliff-nesting species were located by visual inspection of cliff habitat; tree nests were often visible from the river as we floated past.

Observation of the territorial behavior of single or paired Common Black-Hawks was useful in determining the

Table 1. Raptors observed along the Rio Bavispe and the Rio Yaqui, in Sonora, Mexico, 1987–1988.

	BAVISPE (65 river-km)		YAQUI (80 river-km)		TOTAL (145 river-km)	
	1987	1988	1987	1988	1987	1988
Black Vulture (*Coragyps atratus*)	77	141	54	64	131	205
Turkey Vulture (*Cathartes aura*)	122	67	179	57	301	124
Bald Eagle (*Haliaeetus leucocephalus*)	—	—	4	4	4	4
Sharp-shinned Hawk (*Accipiter striatus*)	1	1	2	4	3	5
Cooper's Hawk (*Accipiter cooperi*)	—	2	1	1	1	3
Common Black-Hawk (*Buteogallus anthracinus*)	37	42	15	16	52	58
Gray Hawk (*Buteo nitidus*)	—	—	1	—	1	—
Red-tailed Hawk (*Buteo jamaicensis*)	11	3	13	8	24	11
American Kestrel (*Falco sparverius*)	1	—	2	—	3	—
Peregrine Falcon (*Falco peregrinus*)	2	—	2	—	4	—
Prairie Falcon (*Falco mexicanus*)	2	—	—	—	2	—
No. of species	8	6	10	7	11	7
Total individuals	253	256	273	154	526	410
Individuals/km	3.8	3.9	3.4	1.9	3.6	2.8

number of pairs present, particularly along the Rio Bavispe. Single or paired adults would regularly precede or accompany us, screaming loudly, as we floated downstream through their territory. The adult(s) would break away and fly back upstream after a certain point, which we interpreted to be the territorial boundary. Here, the raptors were often replaced by other single or paired adults which would likewise precede or accompany us through their territory. Constant observation of the activity patterns of Common Black-Hawks allowed us to estimate their population size along the river. Nests attended by single or paired adults were interpreted to indicate the center of activity of a pair. Single adults exhibiting territorial behavior were interpreted as a pair, unless single adults were observed <1 km from another single adult exhibiting territorial behavior. In the latter case, the two adults may have been paired but were temporarily in different areas of their territory. Pairs of Common Black-Hawks were not included in the census as long as they continued to fly downstream ahead of the advancing boats, but only when they were seen to fly back upstream or away from the river on a course that would not result in their being counted twice.

RESULTS

A total of 526 individuals of 11 raptor species were observed along the two rivers in 1987; 410 individuals of seven species in 1988 (Table 1). Mean values of 3.6 and 2.8 individuals/km occurred in the study area in 1987 and 1988, respectively. Turkey Vulture (*Cathartes aura*) and Black Vulture (*Coragyps atratus*) were the two most abundant species encountered (Table 1). The next most abundant species was the Common Black-Hawk, a common nesting species.

We observed different patterns of habitat occupation among selected raptor species (Table 2). Black Vultures were almost entirely associated with disturbed areas, while Turkey Vultures were primarily associated with riparian areas dominated by Mesquite and Pithecellobium. Common Black-Hawks were also largely found in riparian areas dominated by Mesquite and Pithecellobium. Bald Eagles (*Haliaeetus leucocephalus*) and Peregrine Falcons (*Falco peregrinus*) occurred at sites with suitable cliffs, while Red-tailed Hawk (*Buteo jamaicensis*) observations were at both mountain cliffs and riparian areas dominated by Mesquite and Pithecellobium. The abundance of different habitats within the study area was not examined, precluding a quantitative comparison of habitat preferences.

We observed only four species nesting in the study area, although more species may nest during summer. Two occupied Bald Eagle nests were attended by adults in both 1987 (Brown 1988) and 1988. An occupied Peregrine Falcon eyrie was attended by two adults in 1987, but was unoccupied in 1988. Courtship was observed at two probable Red-tailed Hawk nests in 1987 and 1988 where incubation had

Table 2. Proportions of raptors observed in five riparian habitats along the Rio Bavispe, and Rio Yaqui, Sonora, Mexico, 1987.

SPECIES	NUMBERS OF INDIVIDUALS	PITHECELLOBIUM/ MESQUITE	GOODDING WILLOW/ PITHECELLOBIUM	MOUNTAIN/ CLIFFS[a]	DISTURBED AREAS[b]
Black Vulture	131	0.04	0	0	0.96
Turkey Vulture	306	0.57	0.02	0.13	0.28
Bald Eagle	4	0	0	1.0	0
Common Black-Hawk	52	0.70	0.25	0.03	0.02
Red-tailed Hawk	24	0.38	0.04	0.58	0
Peregrine Falcon	4	0	0	1.0	0
Total	521	224	20	64	213

[a] Mountain/cliffs were largely associated with upland vegetation.
[b] By human influence (i.e. fields, pastures, cattle-ranches).

not yet begun. The fourth nesting species was the Common Black-Hawk, which exhibited courtship behavior and strong territorial behavior during the study period. Five and seven probable Common Black-Hawk nests were located in 1987 and 1988, respectively, although incubation had evidently not yet begun for most pairs. Common Black-Hawk was the most abundant riparian-nesting raptor in the study area, where it occurred at densities of up to 0.35 pairs/km along the Rio Bavispe (Table 3).

DISCUSSION

We observed a proportionately greater concentration of Turkey Vultures and Black Vultures than other raptors on the Rio Yaqui. These species are clearly associated with human activities (Table 2).

Table 3. Pairs of Common Black-Hawks and their density/river-km on the Rio Bavispe, and Rio Yaqui, Sonora, Mexico, as determined through downriver continuous transect surveys performed in late March and early April, 1987 and 1988. Single adults exhibiting territorial behavior were counted as a pair.

	RIO BAVISPE		RIO YAQUI		TOTAL	
YEAR	NO.	DENSITY[a]	NO.	DENSITY	NO.	DENSITY
1987	23	0.35	8	0.10	33	0.22
1988	21	0.32	8	0.10	30	0.20

[a] Density expressed as a number of pairs/km.

The greatest concentrations (up to 50 individuals/site) of Black Vultures were observed near small villages or ranches. The primary difference between the 1987 and 1988 abundance of vultures in the study area was apparently due to greater numbers of Black Vultures near the ranches and villages in 1988, and greater numbers of Turkey Vultures overall in 1987. These differences may have been due to the timing of vulture migration during the two study years, since most of the vultures observed were probably migrants.

Lower raptor density on the Rio Yaqui may be explained by the presence of humans *per se*, or subtle habitat differences between the two rivers. Direct human interference of sensitive raptors is a well-documented detriment to their occurrence (Newton 1979, Thiollay 1984, 1985). The Rio Yaqui experiences more human disturbance than the Rio Bavispe. However, the Rio Bavispe has also experienced substantial human-related modification (i.e., increase in the extent of riparian woodland due to the Angostura Reservoir). These modifications apparently increased the complexity and extent of the riparian environment.

The Common Black-Hawk was a specialist in the use of habitats not favored by other species (dense riparian woodland dominated by Mesquite and Pithecellobium). This habitat was most developed along the Rio Bavispe, where the highest nesting density of Common Black-Hawks occurred (Table 3). Their high density there may have been associated with the increase in riparian habitat brought about by the construction and operation of the Angostura Reservoir.

Little comparative information on Common Black-Hawk density exists from other portions of its range (8 pairs/3000 ha, Palma Sola, Veracruz; Thiollay 1978), but its abundance on this 65-km stretch of the Rio Bavispe represents the highest reported for this species in Mexico. Densities reported in Table 3 should be conservatively interpreted as minimum population sizes. Only one survey was made each year, when several surveys per nesting season would have provided more accurate information.

Common Black-Hawks are restricted to riparian habitat in the arid Southwest (Millsap 1981), and our limited observations on the configurations of their territories in the study area suggested linear territories nearly equally spaced along the Rio Bavispe. Their affinities for riparian habitat, territorial responses to intruders early in the breeding season, and nature of the habitat they occupy suggest that surveys by boat, when feasible, may be an efficient method of censusing Common Black-Hawk populations.

The occurrence of the two rarer nesting species, Bald Eagle and Peregrine Falcon, was of special interest. The Rio Yaqui drainage is the only known locality on the mainland of Mexico (excluding Baja California) where Bald Eagles are known to nest (Brown et al. 1987, Brown 1988). Two young apparently fledged from one of the occupied nests in 1987, and both nests contained two young near fledging in 1988, suggesting that the quality of the Rio Yaqui territories was adequate. Swenson et al. (1986) found that a stable food source appeared to be the most important factor influencing selection of nesting territories by Bald Eagles, but the presence of suitable sites for nest-placement is also critical (McEwan and Hirth 1979). We observed many fish in the Rio Yaqui near the two Bald Eagle nests. Both nests were located on high cliffs above the river.

The status and abundance of Peregrine Falcons in Sonora is poorly known (Hitchcock 1977). The single occupied eyrie we observed along the Rio Bavispe in 1987 suggested that this species was rare in the study area, although other pairs could have gone undetected in our survey.

ACKNOWLEDGMENTS

Special thanks are due to Alfredo Ortega, M.S. Laura Arriaga, and Peter L. Warren for their comments on previous drafts of this manuscript. S. Anderson, J. Arenas, W. Leibfried, R. Mesta, S. Reyes, and P. Warren gave valuable assistance in the field. The illustration is by R. Lomeli. Financial support was provided by the U.S. Bureau of Reclamation, the Salt River Project, and Secretaria de Programacion y Presupuesto and Centro de Investigaciones Biologicas of Mexico.

LITERATURE CITED

BROWN, B.T. 1988. Additional Bald Eagle nesting records from Sonora, Mexico. *J. Raptor Res.* 22:30–32.

———, P.L. WARREN AND L.S. ANDERSON. 1987. First Bald Eagle nesting record from Sonora, Mexico. *Wilson Bull.* 99:279–280.

FRIEDMANN, H., L. GRISCOM AND R.T. MOORE. 1950. Distributional checklist of birds of Mexico, Part 1 Pacific Coast Avifauna No. 29. Cooper Ornithol. Club, Berkeley, California.

FULLER, M.R. AND J.A. MOSHER. 1981. Methods of detecting and counting raptors: a review. *Studies in Avian Biol.* 6:235–246.

HITCHCOCK, M.A. 1977. A survey of the Peregrine Falcon population in northwestern Mexico, 1976–77. Contrib. No. 40, Chihuahuan Desert Research Institute, Alpine, Texas.

MCEWAN, L.C. AND D.H. HIRTH. 1979. Southern Bald Eagle productivity and nest site selection. *J. Wildl Manage.* 43:585–594.

MILLSAP, B.A. 1981. Distributional status of falconiformes in west-central Arizona, with notes on ecology, reproductive success, and management. Tech. Note 355, U.S.D.I. Bureau of Land Management, Phoenix, Arizona.

NEWTON, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, SD.

SWENSON, J.E., K.L. ALT AND R.L. ENG. 1986. Ecology of Bald Eagles in the greater Yellowstone ecosystem. Wildlife Monogr. 95.

THIOLLAY, J.M. 1977. La migration d'automne sur la cote orientale du Mexique. *Alauda* 45:344–346.

———. 1978. Comparaisons entre les peuplements de falconiformes des plaines cotieres du Mexique et de Cote D'Ivoire. *Le Gerfaut* 68:139–162.

———. 1979. L'importance d'un axe de migration: la cote est du Mexique. *Alauda* 47:235–245.

———. 1980. Spring hawk migration in eastern Mexico. *Raptor Res.* 14:13–20.

———. 1984. Raptor community structure of a primary rain forest in French Guiana and effect of human hunting pressure. *Raptor Res.* 18:117–122.

———. 1985. Composition of falconiform communities along successional gradients from primary rainforest to secondary habitats. Intl. Council for Bird Preservation, Tech. Publ. No. 5:181–190.

TURNER, R.M. AND M.M. KARPISCAK. 1980. Recent vegetation changes along the Colorado River between Glen Canyon Dam and Lake Mead, Arizona. U.S Geological Survey Prof. Pap. 1132, U.S. Government Printing Office, Washington, D.C.

WETMORE, A. 1943. The birds of southern Veracruz, Mexico. *Proc. U.S. Nat. Mus.* 93:215–340.

WHITE, S. 1948. The vegetation and flora of the region of the Rio Bavispe in northeastern Sonora, Mexico. *Lloydia* 11:229–302.

Received 19 December 1989; accepted 5 July 1990